Foam-Scatter: a workshop on foam characterization

Report of Contributions

Contribution ID: **2** Type: **not specified**

Crystalline particles from fatty components as efficient non-aqueous foam stabilizer

Liquid foams are complex colloidal systems based on gas bubbles dispersed in a liquid continuous phase 1.Two different categories of liquid foams exist: aqueous or non-aqueous. In contrary to aqueous foams, which have been extensively studied, non-aqueous foams represent a new promising emerging field 1. Two types of non-aqueous foams are gaining interest: oil foams based on vegetable oil (oleofoams) and alcohol-based foams 2,3. Oleofoams are a promising option to develop new food products combining both a reduced fat content and new appealing textures and sensorial properties. Alcohol-based foams are gaining interest nowadays since the global pandemic due to COVID-19 and the frequent use of alcohol-based hand sanitizers as recommended by the World Health Organization. The main difference between aqueous and non-aqueous foams comes from the relatively large difference in the surface tension of the solvents 1. For non-aqueous systems, the low surface tension makes the adsorption of hydrocarbon-based surfactants energetically unfavourable. One way to produce and stabilize non-aqueous foams is to use surfactant crystalline particles, which can adsorb at the air-liquid surface 4.

In this talk, we will present how natural fatty acids crystalline particles can lead to the production and stabilization of both oleofoams and alcohol-based foams 2,5. We will illustrate how X-ray scattering techniques are useful to characterize these liquid foams. The formation and stabilization mechanisms of these two types of non-aqueous foams are the same and based on the adsorption of fatty acid crystalline particles at the air-liquid surface, which reduce the bare surface area by their presence rather than lowering the surface tension 4. The key parameter for fatty acid crystals to adsorb at the air-non-aqueous liquid surface is to exhibit a suitable three-phase contact angle below 90°. These foams are ultrastable due to the dense layer of adsorbed crystals at bubble surfaces that considerably reduce both disproportionation and coalescence.

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Primary author: FAMEAU, anne-laure (INRAE)

Co-authors: MA, Yingzhen (2. Louisiana State University, Cain Department of Chemical Engineering, Baton Rouge, USA); BHARTI, Bhuvnesh (2. Louisiana State University, Cain Department of Chemical Engineering, Baton Rouge, USA); CALLAU, Marion (CEA, Saclay, LIONS)

Presenters: FAMEAU, anne-laure (INRAE); MA, Yingzhen (2. Louisiana State University, Cain Department of Chemical Engineering, Baton Rouge, USA)

Session Classification: Oral Session

Contribution ID: **3** Type: **not specified**

SANS technique: a complementary tool to study the stability of foams

Foams are muli-scale non-equilibrium systems so that it is still difficult to predict their foamabilities and metastabilities. In order to better understand the physico-chemical factors that affect the foams kinetics at different structural scale, it was necessary to develop coupled techniques that would provide structural informa+on on the foam within a column and from nanometric up to macroscopic scale.

In this work, the first objective was to develop this new device which allows the simultaneous data collection from a small angle neutron scattering diffractometer, from an optical camera and from an electrical conductivity meter to measure the conductivity, all of them at a chosen heigh from the solution.
electrical conductivity meter to measure the conductivity, all of them at a chosen height. The analysis of these mesoscopic and macroscopic datas obtained simultaneously enable us to better understand the correlation between the mechanisms of drainage, ripening and coalescence involve at the different scales in the aging of the foam.

Primary authors: CHIAPPISI, Leonardo; DIAT, Olivier; LAMOLINAIRIE, Julien

Presenter: LAMOLINAIRIE, Julien

Session Classification: Oral Session

Contribution ID: **4** Type: **not specified**

Imaging 3D foam flows using fast X-ray tomography: hopper flow and plate-plate rheometer

Liquid foams are dispersions of gas bubbles in close contact inside a liquid phase. They are found in various industrial applications including food, cosmetics, oil recovery, or soil remediation. They belong to the class of soft glassy materials that are known to exhibit peculiar rheological behaviors, like nonlinear and non-local dynamics [Goyon et al., Nature (2008)], due to plastic rearrangements mechanisms at the scale of the microstructure, here the bubbles. If some mechanisms have been identified in simulation [Evans et al., Phys. Rev. Lett. (2013)], there is no experimental validation up to now for 3D foams. In fact, foams are highly dispersive to optical wavelengths and are challenging to image in 3D. Recently, fast X-ray microscopic tomography has succeeded in extracting both the deformation and displacement fields of bubbles while flowing around an obstacle [Raufaste et al., EPL (2015)], which opens new opportunities for studying 3D liquid foam rheology.

We will mostly present 3D foam flows through a hopper, e.g. an hourglass-like constriction. Monodisperse bubbles, 300 μm in diameter, were produced by a microfluidic setup, and pushed through a hopper. For each experiment, high-resolution tomograms are recorded every 0.214 s for 10 s. Each tomogram covers a volume of 5.9 × 5.9 × 5.3 mm^3 with a voxel edge length of 2.92 μm. We will present the specific 3D image analysis novel tools developed to reconstruct the geometry of the bubbles from raw tomograms. Bubble displacement and deformations maps will be shown. Velocity fields will be compared to the ones of simple models to understand the interplay between the bubble deformations and the macroscopic flow; in particular, we will show that our new analysis tools unravel nontrivial effects at the constriction exit. Finally, we will present how plastic events can be tracked in such systems in order to study in a near future how they relax stress in their vicinity or on a larger scale.

We will also present preliminary observations of very promising recent experiments of foams subjected to a rheometric flow in a plate-plate rheometer while 3D imaged in real time at the TOMCAT facility.

Primary authors: SCHOTT, Florian (Department of Mechanical Engineering, LTH, Lund University, Sweden); DOLLET, Benjamin (Laboratoire Interdisciplinaire de Physique, CNRS and Univ. Grenoble Alpes, France); CLAUDET, Cyrille (Institut de Physique de Nice, CNRS/Univ. Côte d'Azur, France); SANTUCCI, Stéphane (Laboratoire de Physique de l'ENS Lyon, CNRS/ENS Lyon, France); RAUFASTE, Christophe (Institut de Physique de Nice, CNRS/Univ. Côte d'Azur, France); MOKSO, Rajmund (MAX IV Laboratory, Lund University, Sweden)

Presenter: DOLLET, Benjamin (Laboratoire Interdisciplinaire de Physique, CNRS and Univ. Grenoble Alpes, France)

Session Classification: Oral Session

Contribution ID: **5** Type: **not specified**

Physics of oat drink foams: influence of pre-treatment on foam stability

Nowadays, the demand for vegan and sustainable food products is rising and oat drink has become a popular milk-alternative. For various kinds of applications, a capacity to form creamy, stable, homogeneous foams is required for such drinks. Such macroscopic foam properties are highly dependent on molecular interactions at the air-water interface and protein kinetics within the lamellae. However, the underlying structure-function relationships between these molecular interactions and the resulting macroscopic foam properties are not yet fully understood, especially for multicomponent systems like plant-based beverages. Like many other food foams, oat drink foams belong to the protein-based foams with 12S seed storage protein being the major protein present in oats. In this study, foams of an organic, vegan, barista oat drink were investigated that only contained water, oats, canola oil and salt.

Here, the influences of protease treatment, heat treatment, canola oil addition as well as homogenization parameters on the foam properties were investigated. After foaming the oat drink samples, the foam was investigated by measuring foam heights over time. To underline these measurements also light microscopy, photography and particle size measurements were applied to compare with bubble size evolution and oil droplet distribution.

It was found that protease treatment led to a higher foaming capacity but lower foam stability and that heat treatment decreased the stability of the oat drink foam. Furthermore, addition of small contents of canola oil enhanced the foaming capacity of the oat drink. However, the foam stability decreased with increasing canola oil content. Moreover, a higher number of revolutions per minute and longer duration of homogenization treatment led to a more homogeneous emulsion and a higher foaming capacity as well as foam stability.

These findings contribute to a better understanding of the physical interactions determining the enhancement of foaming capacity and foam stability of oat drinks.

Primary authors: HEGE, Judith (Max Planck Institute for Polymer Research); Prof. VILGIS, Thomas A. (Max Planck Institute for Polymer Research); SCHLICHTING, Antonia-Louisa (Max Planck Institute for Polymer Research); REEH, Jana (Max Planck Institute for Polymer Research)

Presenter: HEGE, Judith (Max Planck Institute for Polymer Research)

Session Classification: Oral Session

Contribution ID: **8** Type: **not specified**

Probing soapy interface properties with linear and nonlinear optics

Features of amphiphilic molecules at interfaces are of crucial interest to understand macroscopic foam properties. For example, literature shows that one can change the rigidity of a soapy interface, and thus a foam life-time, only by a little change in the formulation of the soapy solution. If the link between microscopic and macroscopic properties of covered interfaces is well established, it is not always well understood essentially because of the lack of techniques that gives access to the composition and the dynamics of such interface at molecular scale

We develop optical techniques such as ellipsometry or Second Harmonic Generation (SHG) to question the surfactant organisation at liquid/air interface. Notably, SHG signal is generated only where centro-symmetry is broken and is SHG is thus a tool of choice to study the behavior of amphiphilic molecules adsorbed at air/water interfaces.

In this work, we will present some recent results where ellipsometry and SHG are used to study the concentration and organization of adsorbed surfactant on air/water interfaces at a molecular scale. Those results are discussed by comparison to other experimental characterizations such as surface tension or disjoining pressure measurements, more classically used to probe soapy interfaces.

Primary authors: BAE, Changwoo (Institut Lumière Matière); ALBERT, Samuel (Institut Lumière Matière); BLANC, Baptiste (Institut Lumière Matière); Prof. BENICHOU, Emmanuel (Institut Lumière Matière); BIANCE , Anne-Laure (Institut Lumière Matière); BONHOMME, Oriane (Institut. Lumière Matière)

Presenter: BONHOMME, Oriane (Institut. Lumière Matière)

Session Classification: Oral Session